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(54) **A Method for Manufacturing an Absorbent Material**

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SPECIFICATION

1. Title of the Invention

A Method for Manufacturing an Absorbent Material

2. Claims

A method for manufacturing an absorbent material, which is characterized by the fact that a photopolymerization initiator and a cross-linking agent are mixed into an aqueous solution of a highly absorbent acrylic acid resin monomer, said mixture solution is applied to a travelling fibrous web and irradiation with ultraviolet beams is continually performed, after which guidance into an environment of temperature 50 to 100°C and a relative humidity of at least 40% is performed and polymerization is brought about.

3. Detailed Description of the Invention

(Field of Industrial Utilization)

The present invention concerns a method for manufacturing an absorbent material possessing a highly absorbent resin, which is suitable for disposable diapers, etc. More specifically, the present invention concerns a method for manufacturing an absorbent material in the form of a soft and compact sheet, which imparts a high degree of latent absorption capacity to the highly absorbent resin and which can, furthermore, absorb a great amount of urine in a short time.

(Prior Art)

In recent times, so-called "disposable hygenic materials" such as disposable diapers and sanitary napkins have been widely used by means of the diffusion of highly absorbent resins.

Disposable diapers, which are one type of such disposable hygenic materials, are normally composed of a water-permeable top sheet on the side which makes contact with the skin of the user, a liquid-absorbent support layer positioned in the center and a water-impermeable top sheet on the outside.

In the past, an absorbent material with a structure in which a highly absorbent resin is fixed to a fibrous web has been proposed as the absorbent material in the abovementioned liquid-absorbent layer. This absorbent material is manufactured by applying an aqueous solution of a highly absorbent acrylic acid resin monomer to a fibrous web and continuously bringing about polymerization. However, with this method, it is essential that polymerization be brought to completion within an extremely short period of time; a method in which an oxidizing agent such as hydrogen peroxide is mixed into the highly absorbent acrylic acid resin monomer aqueous solution in advance and this mixture is applied to the fibrous web, after which an aqueous solution of a reduced form such as L-ascorbic acid is sprayed onto the monomer aqueous solution in the form of fine grains and polymerization is abruptly brought to completion by means of a redox-type (oxidation-reduction type) polymerization initiation reaction and a method in which a highly absorbent acrylic acid resin monomer aqueous solution is applied to a fibrous web, after which irradiation is performed with an electron beam and polymerization is brought to completion in a single step have been proposed for this purpose. However, with the former method, because the monomer aqueous solution of a relatively low viscosity which has been applied to the fibrous web is scattered from both surfaces of the fibrous web by means of a spraying gas current and a reducing agent aqueous solution which is sprayed, and resinification occurs in a state such that the fibrous web has been crushed, it has only been possible to obtain thin, hard absorbent materials. Furthermore, when this method is used, polymerization is initiated from the surface component of the monomer drops, to which an aqueous solution of a reducing agent in a fine-grain form has become attached, the moisture content of the inner component of the monomer drops evaporates owing to polymerization and generation of heat and, because heat polymerization progresses in a state of having decreased, the polymerization reaction does not progress to the inner component of the monomer drops in a uniform fashion; as a result, it has only been possible to obtain resins with low absorption capacities.

Furthermore, although with the latter method, in which irradiation is performed with an electron beam, the polymerization reaction progresses in a uniform fashion in the surface component and inner component of the monomer drops, high-density cross-linking occurs in the obtained resin because the energy of the electron beam is high, so that the absorption capacity decreases.

(Problems Which The Invention Attempts To Solve)

In light of the abovementioned conditions, the purpose of the present invention is to provide a method for manufacturing an absorbent material which possesses excellent absorption capacity and bulkiness owing to the fact that a highly absorbent acrylic acid resin monomer aqueous solution into which a photopolymerization initiator has been mixed and dissolved is applied to a fibrous web, after which, with the bulk of the fibrous web maintained by means of ultraviolet radiation without the addition of physical power from outside such as spraying, the surface layers and inner layers of the monomer drops are subjected to polymerization in a uniform fashion while excess high-density cross-linking is held in check.

(Means Used to Solve the Abovementioned Problems)

As a means of achieving the abovementioned purpose, the present invention is a method for manufacturing an absorbent material, which is characterized by the fact that a photopolymerization initiator and a cross-linking agent are mixed into an aqueous solution of a highly absorbent acrylic acid resin monomer, said mixture solution is applied to a travelling fibrous web and irradiation with ultraviolet beams is continually performed, after which guidance into an environment of temperature 50 to 100°C and a relative humidity of at least 40% is performed and polymerization is brought about.

(Actions)

When the abovementioned method is used, an absorbent material possessing excellent absorption capacity and bulkiness can be continuously obtained at a high rate of productivity by subjecting the surface layers and inner layers of the monomer drops to polymerization in a uniform fashion while excess high-density cross-linking is held in check, with the bulk of the fibrous web being maintained by means of ultraviolet radiation.

Below, a detailed explanation is provided using drawings of the present invention.

Figure 1 is a drawing which shows a manufacturing device which can be suitably used for executing one example of the manufacturing method of the present invention. In this figure, symbol 1 is a fibrous web, 2 is a monomer aqueous solution, 3 is an ultraviolet beam irradiation device and 4 is a polymerization tank.

When this device is used and an absorbent material is manufactured, first, monomer aqueous solution 2, to which a photopolymerization initiator and a cross-linking agent (a cross-linking monomer) have been added, is applied to the surface fibrous web 1, which moves at a prescribed speed, by means of nip-type coating roller 3. Next, fibrous web 6, to which monomer aqueous solution 2 has become attached, is guided into ultraviolet beam irradiation device 3 and subjected to irradiation with ultraviolet beams inside ultraviolet beam irradiation device 3, and a radical polymerization reaction is initiated in a photopolymerization initiator contained within monomer aqueous solution 2.

Fibrous web 6, to which monomer aqueous solution 2 has become attached and which has been subjected to ultraviolet beam irradiation inside ultraviolet beam irradiation device 3, is guided into polymerization tank 4, which is continuously maintained in an atmosphere of temperature 50 to 100°C and relative humidity 40% or above by means of heater 7 and blower 8. Inside ultraviolet beam irradiation device 3, a radical polymerization reaction is initiated by means of ultraviolet beam irradiation, and inside polymerization tank 4, monomer aqueous solution 2, which has become attached to the structural fibers of fibrous web 1, undergoes a polymerization reaction in the surface layer components and inner components of the monomer drops while [the reaction] is being accompanied by the generation of heat.

As a result, the polymerization reaction of monomer aqueous solution 2 is completed within a few seconds and absorbent material A, with a structure in which a highly absorbent resin derived from the polymer of monomer aqueous solution 2 has become fixed onto the surfaces of the structural fibers of fibrous web 1, is obtained.

Because the highly absorbent resin of the absorbent material (A) thus obtained is a moisture-containing polymer which contains a moisture component of approximately 10 to 30% and, furthermore, contains a large amount of monomer which has remained unreacted; in this manufacturing example, the absorbent material is subjected to irradiation with an electron beam and an ultraviolet beam and the polymerization of the highly absorbent resin is carried out to completion in order to raise the performance of the abovementioned absorbent material A. That is to say, as shown in Figure 1, the highly absorbent resin of absorbent material A is further subjected to polymerization by guiding absorbent material A, which is removed from polymerization tank 4, into electron beam irradiation device 9 and subjecting it to irradiation with an electron beam, and then guiding it to ultraviolet beam irradiation device 10 and subjecting it to irradiation with an ultraviolet beam. By means of these coupled operations, absorbent material B, which possesses a highly absorbent resin with a high degree of polymerization, can be obtained.

Furthermore, during electron beam irradiation by means of electron beam irradiation device 9 and ultraviolet beam irradiation by means of ultraviolet beam irradiation device 10, because the [amount of] remaining unreacted polymer can be decreased when the moisture component within the highly absorbent resin of absorbent material A is adjusted [literally, "subjected to humidity conditioning"] to 25 to 35 wt %, water dissemination should be carried out by suitable means such as a water dissemination device equipped with a revolving brush (11), and the highly absorbent resin of absorbent material A should be subjected to humidity conditioning.

Furthermore, although electron beam irradiation device[sic] and ultraviolet beam irradiation were carried out on absorbent material A in the earlier example, a polymerization promotion operation (treatment for decreasing the amount of remaining unreacted polymer) for absorbent material A should be performed in accordance with necessity. Furthermore, the method thereof is not limited to electron beam irradiation and ultraviolet beam irradiation; either one of electron beam irradiation and ultraviolet beam irradiation may be performed. In addition, the degree of polymerization of the highly absorbent resin may be increased by heating absorbent material A.

Furthermore, when the degree of polymerization of the highly absorbent resin is increased by the heating of absorbent material A or, alternatively, absorbent material B [uncertain translation], it is also possible to increase the absorption capacity of the absorbent material by disseminating a solution of a cross-linking agent possessing two or more functional groups capable of reacting with carboxyl groups within the molecule onto the surface of the absorbent material by means of suitable means such as a rotating brush, guiding [this product] into a heating device and forming cross-linkages in the resin surface at 100 to 200°C.

Furthermore, as an improvement for the absorbent material, it is also desirable to improve the wetting by applying a surfactant to the structural fibers and to the highly absorbent resin which is in the form of a water-containing polymer before the drying of the absorbent material.

However, the highly absorbent acrylic acid resin monomer aqueous solution used in the present invention should be an aqueous solution of acrylic acid or of a mixture of acrylic acid and methacrylic acid; among these possibilities, a solution in which 20 to 95% of all carboxyl groups have been subjected to partial neutralization [literal translation] in an alkali metal salt or an ammonium salt is favorable. When the degree of this partial neutralization is excessively high, it becomes difficult to increase the concentration of the aqueous solution and, consequently, because the cross-linking reaction is suppressed and the proportion of the resin component of the aqueous solution becomes high, a gel film with cold-blocking properties [literal translation] is produced on the surface of the resin. Furthermore, it is undesirable from the standpoints of safety and sanitation for the degree of partial polymerization to be excessively high, because the swollen gel exhibits weak alkalinity. On the other hand, when the degree of partial neutralization is excessively low, the absorption capability of the resin markedly decreases.

In the neutralization of such an acrylic acid monomer, an ammonium salt or the bicarbonate salt or the hydroxide of an alkali metal can be used; however, sodium hydroxide and potassium hydroxide are desirable because of ease of procurement on an industrial scale, cost and safety. Among these possibilities, potassium hydroxide is optimal because it allows for the elevation of the concentration of the aqueous solution of the acrylic acid monomer. Moreover, it is desirable that the concentration of this acrylic acid monomer aqueous solution be at

least 35 wt %. Because the degree of polymerization of the resin increases to a great extent and the amount of the monomer which becomes attached to the fibrous web can increase when the concentration is high, it is desirable to use a concentration slightly lower than the saturation concentration pertaining to the temperature of utilization, as long as there are no other difficulties.

Concerning the absorbent material pertaining to the present invention, the amount of urine which is effectively absorbed in a fibrous web of METSUKE [now and hereafter, a transliteration] 10 to 100 g/m^2 (under pressure of 0.5 psi) is 1 g per 15 to 45 cc of a material in which a highly absorbent resin has been fixed. However, a common absorbent material for use in disposable diapers is a short sheet of width 15 cm and length 40 cm (area approximately 0.06 m^2), so that in order to maintain absorbancy through 4 to 5 repetitions at approximately 50 cc of the infant's urine per repetition, it becomes necessary for the amount of the highly absorbent resin to be at least twice the weight of the fibrous web itself.

In the present invention, when 0.01 to 1.0 wt % with respect to the acid monomer of a cross-linking monomer possessing within the molecule two or more double bonds capable of copolymerization with the acrylic acid monomer is added to the monomer solution as a cross-linking agent and the formation of molecular cross-linkages is brought about, the form of the swelling gel can be stabilized. This cross-linking monomer is not particularly limited as long as it is soluble in the acid monomer; examples include ethylene glycol diacrylate, ethylene glycol dimethacrylate, diethylene glycol diacrylate, diethylene glycol dimethacrylate, polyethylene glycol diacrylate, polyethylene glycol dimethacrylate, polypropylene glycol diacrylate, polypropylene glycol dimethacrylate, glycerine triacrylate, glycerine trimethacrylate, N,N'-methyl bisacrylamide, N,N'-methyl bismethacrylamide, diallyl phthalate, diallyl fumarate, diallyl terephthalate, triallyl cyanurate, triallyl isocyanurate and triallyl phosphate. Among these possibilities, polyethylene glycol (meth)acrylate and N,N'-methylene bisacrylamide are desirable. When the amount of these cross-linking monomers added is below 0.01 wt % with respect to the acid monomer, although the absorption capacity becomes extremely high, the swelling gel assumes a paste form and liquefies, so that the ability to maintain the form of the gel becomes poor and it becomes impossible to use the material in disposable diapers. Furthermore, when 1.0 wt % is exceeded, the

maintainability of the form of the gel is improved, but the absorption capacity decreases.

Furthermore, as functional groups for the purpose of controlling the speed of polymerization and the density of cross-linking (distance between cross-linked molecules) in the present invention, carboxylic acid and salts thereof, phosphoric acid and salts thereof, sulfonic acid and salts thereof and an unsaturated ethylenic monomer possessing a hydroxyl group, an amide group, a pyridine ring or another [group] can be subjected to copolymerization. Examples include (meth)acrylic acid (salts), itaconic acid (salts), vinylsulfonic acid (salts), polyethylene glycol (meth)acrylate, acrylamide and 2- or 4-vinylpyridine.

Furthermore, in the present invention, the absorption capacity of the highly absorbent resin may be improved by adding a high molecular weight polysaccharide into the monomer aqueous solution and carrying out graft polymerization in which the polysaccharide is made into a trunk polymer. The graft polymer which is formed possesses a structure in which the polysaccharide is made into the trunk and possesses a three-dimensional structure in which self-cross-linking has occurred. Examples of high-molecular weight polysaccharides which can be used for this trunk polymer are not limited to naturally occurring polysaccharides, and include denaturation products thereof; besides hydroxyethylcellulose, cellulose, guar gum, locust bean gum, mannan and starch sugars such as potato starch and corn starch, examples include various denaturation products, such as hydrolysis products, oxides, alkyletherification products, aryletherification products, oxyalkylation products, carboxymethylation products, aminoethyletherification products and organic acid esterification products, of these polysaccharides.

It is desirable for the amount of these polysaccharides added to be in a range of 1 : 0.02 to 1 : 0.05 by acid monomer to sugar unit. A reaction temperature of 50 to 100°C is favorable, and joint use with a cross-linking monomer is also possible.

Furthermore, the adhesion of monomer aqueous solution 2 used in the present invention to fibrous web 1 can be improved by using a compound of at least 1 member selected from water-soluble high molecules such as sodium polyacrylate, polyvinylpyrolidone and polyvinylalcohol, high-molecular polysaccharides such as hydroxyethylcellulose and carboxymethylcellulose and ultrafine-grain inorganic

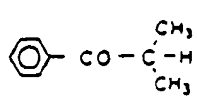
compounds such as colloid-form silica, an agent which imparts thixotropic properties, as a viscosity controlling agent in monomer aqueous solution 2.

Moreover, it is desirable for the viscosity of monomer aqueous solution 2 to be in a range of 2 to 200 cps. Below 2 cps, monomer aqueous solution 2, once attached to fibrous web 1, immediately slips down along the fiber spindle of fibrous web 1 and large drops form in many places at which [the fibers of] fibrous web 1 intersect. On the other hand, it is undesirable for 200 cps to be exceeded because, under such conditions, the monomer aqueous solution which has been applied to fibrous web 1 forms a film.

In the present invention, a highly absorbent acrylic acid resin monomer is subjected to irradiation with an ultraviolet beam in a photopolymerization initiator, and polymerization is initiated owing to the radicals which are generated. Because this method of polymerization involves a lower activation energy for radical generation than a thermal cracking-type radical polymerization method and allows polymerization to be explosively [literal translation] carried out at a relatively low temperature, it is extremely beneficial when an absorbent material is manufactured by, as in the present invention, applying monomer aqueous solution 2 while fibrous web 1 is continuously caused to travel and then bringing polymerization to completion in an extremely short time (a few seconds).

For the photopolymerization initiator used in the present invention, widely known substances which are soluble in a highly absorbent acrylic acid resin monomer aqueous solution should be selected and used singly or in a combination of two or more. A benzophenone derivative, an acetophenone derivative, a benzoin derivative or other compounds, as shown in (I) through (XIV) below, are used as this type of polymerization initiator; specifically, phenyl-(2-hydroxy-2-propyl) ketones such as (II), (III), (VI) and (XII) are desirable. However, the present invention is not limited to these possibilities.

(I)



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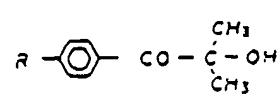

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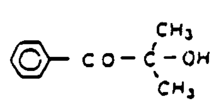

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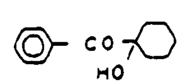
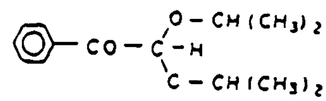
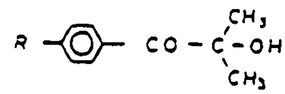
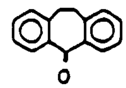
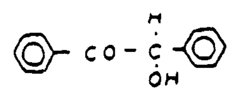
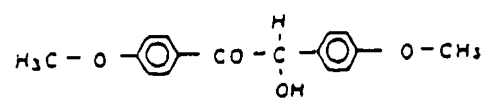


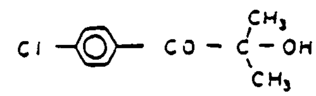
(V) 

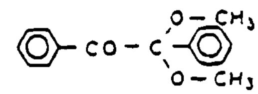
(VI) 

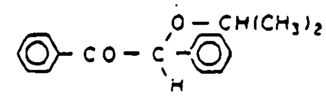
(XIV) 

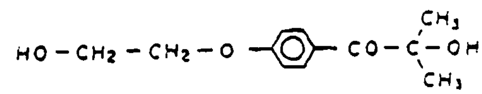
(VII) 

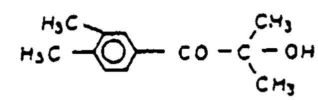
(VIII) 

(IX) 

(X) 

(XI) 

(XII) 

(XIII) 

These photopolymerization initiators should be substances with high solubilities in monomer aqueous solution 2 and high initial polymerization speeds. Furthermore, although the amount of this initiator used can be suitably chosen in accordance with the combination of initiators and the speed of polymerization, it is generally favorable for utilization to be carried out in a range of 0.01 to 5 wt % with respect to the acid monomer. When the amount of the photopolymerization initiator is below 0.01 wt %, the photopolymerization reaction does not progress sufficiently; furthermore, when 5 wt % is exceeded, the effect thereof does not increase even if the amount of initiator is increased.

Because the monomer aqueous solution into which this photopolymerization initiator is mixed does not undergo naturally occurring polymerization, not only an ultraviolet beam as one would expect, but also a visible light beam of maximum wavelength of 700 nm or below, should be maintained in a shielded state at a temperature of 50°C or below and applied to fibrous web 1.

A widely known device can be used as ultraviolet irradiation device 3 used in the present invention. Figure 2 shows one example of ultraviolet irradiation device 3; symbol 12 is a light source and symbol 13 is a reflective mirror. This light source 12 may be a light source capable of irradiation of wavelengths from 250 to 450 nm, such as a beam light source such as a high-pressure mercury lamp or a metal halide lamp, and may be a mercury lamp of lamp input 30 to 240 W/cm. Furthermore, a

radiation dosage of 50 to 10000 millijoules/cm^2 is sufficient, and many mercury lamps, which are line light sources, may be lined up side by side in accordance with the necessary radiation dosage.

Kiss coating by means of coating roller 5 as shown in Figure 3, scattering whereby a rotating brush is used and monomer aqueous solution 2 is disseminated onto the surface of fibrous web 1 as shown in Figure 4, and dipping whereby fibrous web 1 is caused to pass through bath 15 of monomer aqueous solution 2, as shown in Figure 5, can be used as methods for applying monomer aqueous solution 2 to fibrous web 1; however, among these possibilities, kiss coating by means of coating roller 5 is particularly desirable because, with this method, monomer aqueous solution 2 can be applied to fibrous web 1, which is travelling at a high speed, with high efficiency and, furthermore, the amount of monomer aqueous solution 2 applied can easily be controlled. Furthermore, in this application method based on kiss coating, nip-type coating roller 5, which is equipped with at least one pair of coating rollers as shown in Figure 6, can be used as suitable.

During application by means of nip-type coating roller 5, fibrous web 1 is inserted between two coating rollers 5 rotating at the same speed as fibrous web 1 and monomer solution 2 is applied to the surfaces of fibrous web 1 from both sides. Furthermore, it is desirable to use these methods in the present invention because the amount of the monomer aqueous solution applied to fibrous web 1 can be sufficiently increased whether by means of a method based on printing or spraying.

However, when monomer aqueous solution 2 is continuously applied while fibrous web 1 is being fed, it becomes difficult to increase the amount of monomer aqueous solution applied when the travelling speed of fibrous web 1 is 50 m/min or above. As shown in Figure 7, this problem arises from the fact that, when the speed of application becomes high, when fibrous web 1, which has been inserted between coating rollers 5, has been impregnated with monomer aqueous solution 2, which is in the valley between the two rollers, air from fibrous web 1 is successfully stopped inside fibrous web 1 without being removed, so that the permeation of monomer aqueous solution 2 is hindered.

Methods such as (1) adding a thickener to monomer aqueous solution 2, (2) modifying the cross-section of the fiber base material and establishing a depression

(groove) in the fiber surface and (3) making the air from fibrous web 1 easy to remove by enlarging the vacant spaces in fibrous web 1 are effective as methods for increasing the amount of monomer aqueous solution 2. Furthermore, it is, naturally, possible to use the phenomenon discussed above and make an absorbent material of a 3-layer structure by applying monomer aqueous solution 2 to only the surface layers of the two sides of fibrous web 1, and to thereby bring about an increase in the urine absorption speed.

In the present invention, monomer aqueous solution 2 is applied to fibrous web 1, after which polymerization is initiated by means of irradiation with an ultraviolet beam. In order to subject the entire fibrous web to irradiation with an ultraviolet beam in a uniform fashion, it is desirable to arrange many irradiation tubes (light source 12) on both sides of fibrous web 1. Monomer aqueous solution 2, which has been applied to fibrous web 1, is subjected to ultraviolet beam irradiation of 50 to 10000 millijoules/cm as discussed above and, furthermore, the product is guided into polymerization tank 4, which has been maintained in an atmosphere of temperature 50 to 100°C and relative humidity 40% or above, and the polymerization reaction is brought to completion.

The form of polymerization tank 4 is not particularly limited; however, when polymerization is brought to completion in a short time while fibrous web 1 is being continuously fed, it is particularly desirable for the reaction to be brought about in polymerization tank 4, which has been maintained at a temperature of 80°C or above and relative humidity of 80% or above by means of a hot air current in which the moisture component has been brought to saturation, while fibrous web 1 is continuously being caused to travel from up to down. At temperatures below 50°C, although the amount of the basic molecule of the obtained resin becomes high and the absorption capacity of the resin increases, a long period of time is required before polymerization is completed. Furthermore, when the temperature exceeds 100°C, a polymerization reaction of a self-cross-linking type arises or the moisture component within the monomer aqueous solution suddenly decreases during polymerization, so that the absorption capacity of the resin decreases. Moreover, when the relative humidity of the polymerization tank is below 40%, the moisture component of monomer aqueous solution 2 decreases during polymerization, so that only a resin of low absorption capacity can be obtained.

However, in the case of a common acrylic acid monomer, a high heat of reaction is generated in accordance with the progress of the reaction, so that there are instances in which local, sudden increases in temperature arise and abnormal reactions occur. However, with the present invention, by using fibrous web 1, which is bulky and possesses favorable gas permeability, as a carrier for monomer aqueous solution 2, the heat of monomer aqueous solution 2 during polymerization is efficiently dispersed outside the system, so that cooling of the heat of reaction is carried out and the temperature distribution becomes uniform; therefore, the difficulties of self-cross-linking rapidly progressing in parts [of the monomer aqueous solution] owing to local increases in temperature and of the bringing about of decreases in the absorption capacity of the obtained absorbent material A can be prevented. Furthermore, it is also possible, by means of the cooling of this heat of reaction, to control the evaporation volatility of the moisture component of monomer aqueous solution 2.

This type of polymerization reaction of an acrylic acid monomer is normally completed in a few seconds (3 to 15 seconds), and approximately 90 to 95% of the monomer is converted into a highly absorbent resin. Then, the highly absorbent resin thus obtained is a water-containing polymer containing a moisture component of approximately 20 wt % and, furthermore, the inner component thereof contains the unreacted monomer in an amount of 5 to 10%. Not only does this remaining partially neutralized acid monomer of acrylic acid or of a mixture of acrylic acid and methacrylic acid bring about a decrease in the absorption capacity of the highly absorbent resin, but also it is undesirable in terms of safety and sanitation because the skin of the infant becomes irritated, causing rashes and inflammation.

The amount of the unreacted monomer remaining within the abovementioned water-containing polymer (the highly absorbent resin) can be efficiently decreased by means of irradiation with an electron beam or an ultraviolet beam, or by heating. Electron beam irradiation is most efficient when the moisture component within the water-containing polymer is approximately 20 wt %. Furthermore, appropriate conditions should be selected with the radiation dose in a range of 2 to 20 megarads. By means of this electron beam irradiation, the amount of monomer remaining in the water-containing polymer can be decreased to 100 ppm or below.

Furthermore, in the case of ultraviolet beam irradiation, because a photopolymerization initiator, specifically a photodisintegrating-type radical initiator, must be present in advance, an aqueous solution of an initiator should be disseminated in the water-containing polymer before ultraviolet beam irradiation. Moreover, when the water-containing polymer is subjected to electron beam irradiation during the preliminary stage of ultraviolet beam irradiation, the addition of the initiator can be reduced because hydrogen peroxide is produced in the water-containing polymer. Because this ultraviolet beam irradiation is most efficient when the moisture content of the water-containing polymer is approximately 30 wt %, it is desirable to perform humidity conditioning in advance by spraying water in a suitable fashion. Ultraviolet beam irradiation in an amount in a range of 50 to 10000 millijoules/cm^2 can reduce the amount of monomer remaining in the water-containing polymer to 100 ppm or below.

In the absorbent material pertaining to the present invention, because so-called "gel block," whereby a paste-form gel forms on the surface layer component, is suppressed owing to the fact that cross-linking density has only increased in the surface layer component of the highly absorbent resin which has been polymerized, urine quickly comes to penetrate the surface layer component as far as the inner component of the highly absorbent resin, so that still more of an increase in the absorption capacity of the absorbent material can be brought about. Examples of cross-linking agents used for such a purpose include polyglycidyl ethers such as polyethylene glycol diglycidyl ether and ethylene glycol diglycidyl ether, which possess two or more functional groups in the molecule which react with carboxylic acids, polyols such as diethylene glycol, triethylene glycol, propylene glycol, glycerin, polyglycerine and erythritol and polyamines such as ethylenediamine.

By adding these cross-linking agents to this water-containing polymer at the water-containing polymer stage and heating, extremely uniform cross-linkages can be formed between molecules in the surface layer of the water-containing polymer; furthermore, the size of the network structure which is formed owing to cross-linkages in accordance with the amount thereof added, among other factors, can be controlled to a certain extent. The cross-linking agent should be used in an amount of 0.01 to 2.0 wt % with respect to the acid monomer. Below 0.01 wt %, the cross-linking effect is diminished; furthermore, when 2.0 wt % is exceeded, the effect based on the addition of the cross-linking agent ceases to increase. Because it is

most convenient, a method based on the dissemination of an aqueous solution of the cross-linking agent is desirable for the imparting of this cross-linking agent to the surface of the highly absorbent resin (water-containing polymer); furthermore, because a cross-linking reaction based on the esterification of a hydroxyl group and a carboxyl group or the amidation of a carboxyl group and an amino group progresses easily to the extent that the temperature is high, it is desirable to carry out heat treatment at 100 to 200°C in conjunction with the drying of the absorbent material.

Furthermore, for the purpose of ameliorating the wetness of the urine which confronts the structural fibers and the highly absorbent resin, it is desirable to impart a surfactant to at least these surfaces. Widely known surfactants can be used for such a purpose; for example, a nonionic surfactant selected from among a polyoxyethylene alkyl ether, polyoxyethylene phenol ether, polyoxyethylene sorbic acid [Translator's note: uncertain term; literally, "sorbitan acid"] ester, a polyoxyethylene alkyl fatty acid ester or a polyoxyethylene oxypropylene block polymer is particularly desirable. The amount of this surfactant to be imparted should be 0.05 to 1.0 wt % with respect to the highly absorbent resin. Furthermore, because they are convenient, dissemination by means of a rotating brush or spraying by means of a spray are desirable as methods for imparting this surfactant.

A fibrous web possessing favorable morphological stability, a high compression recovery factor and large vacant spaces with favorable gas permeability, is desirable as the fibrous web used in the present invention. This type of fibrous web 1 can be obtained by uniformly entangling a thermally fusing-type binder fiber with a base fiber which has as its principal component a bulky and highly elastic fiber, forming a web using means such as carding and, afterwards, causing [the fibers] to thermally fuse with each other.

This base fiber should have a fineness of 1.5 to 20 denier and a fiber length in a range of 32 to 128 mm. When the fineness is below 1.5 denier, a fibrous web possessing a high compression recovery factor and large vacant spaces with favorable gas permeability, as would be desirable for use in the present invention, cannot be obtained; when 20 denier is exceeded, it becomes difficult to sufficiently increase the amount of monomer aqueous solution 2 which adheres [to the fibrous web]. Furthermore, when the fiber length is below 32 mm, the intertwining between

the fibers is weak, so that the web undergoes sheet collapse [now and hereafter, a literal translation] prior to thermal treatment. When 128 mm is exceeded, on the other hand, the intertwining is excessively strong, so that opening and carding at high speeds become difficult. This base fiber should be selected from among fibers such as polyester fibers, polyamide fibers, polypropylene fibers and polyethylene fibers; in particular, because of superiority in terms of fiber performance, polyester fibers are desirable. Furthermore, a bulky and highly elastic base fiber can easily be obtained if the fiber cross-section is made hollow.

Because the form of fibrous web 1 cannot be stabilized when all of the fibers are subjected to fusion by means of thermal treatment, it is desirable to use a composite spinning-type fiber in which a low-boiling point polymer component which undergoes fusion during heat treatment is combined with a high-boiling component as the abovementioned binder fiber. This composite spinning may be of a core-sheath type, a side-by-side type or another type and, furthermore, the fusing point of the low-fusing point polymer component is not particularly limited as long as it is not more than 30°C lower than the fusing point of the high-fusing point polymer component.

Many combinations, such as those of a low-fusing point copolymerizing polyester with polyethylene terephthalate, polyethylene and polyethylene terephthalate, polyethylene and a polyamide, polyethylene and polypropylene, polypropylene and polyethylene terephthalate, and polypropylene and a polyamide, can serve as examples of this type of combination of thermoplastic polymers; however, the possibilities are naturally not limited to these combinations. Furthermore, a binder fiber may be formed by selecting two or more binder fibers from among these combinations. Examples include the combination of a composite spinning fiber derived from polyethylene terephthalate and a copolymerized polyester with a low fusing point and a composite spinning-type binder fiber derived from polyethylene and polyethylene terephthalate. Furthermore, in the case in which a polyester fiber is used in the base fiber, when a composite spinning-type fiber derived from a low-fusing point copolymer polyester and polyethylene terephthalate is used, a fibrous web with extremely favorable morphological stability can be obtained because of the fact that the polyester fibers are made compatible [literal translation] by heat treatment.

It is desirable that the fineness of the binder fibers be 1.5 to 9 denier, and that the fiber length be 32 to 128 mm. When the fibers are excessively fine, the number of fibers increases and there come to be many points of intersection and contact, so that the morphological stability of fibrous web 1 increases and the amount of monomer aqueous solution 2 which adheres to the web increases; conversely, however, the proportion of vacant space is lowered, so that gas permeability becomes poor. Furthermore, when the fibers are not sufficiently fine, the number of fibers decreases and there come to be few points of intersection and contact, so that the morphological stability of the fibrous web is lost. Moreover, when the fiber length of the binder fibers is below 32 mm, sheet collapse can easily occur prior to heat treatment and, when 128 mm is exceeded, opening and carding are decreased.

Furthermore, it is desirable that the compounding ratio of the binder fiber contained within fibrous web 1 be set in a range of 5 to 50 wt %. Below 5 wt %, the morphological stability of fibrous web 1 is insufficient while, when 50 wt % is exceeded, the hand of the fibrous web becomes thin and hard, so that it is not possible to obtain a fibrous web (1) possessing favorable gas permeability and a high proportion of vacant space. During the formation of fibrous web 1 in the present invention, carding, air laying, or other well-known techniques may be used or a combination thereof may be carried out; among these techniques, a method based on carding possesses many strong points such as that 1) a fibrous web possessing large vacant spaces and high compression elasticity can be obtained, 2) wide sheets can be obtained at high speeds with superior productivity, 3) a web sheet of two or more layers can easily be laminated, 4) regulation of METSUKE is easy, 5) a condensing roller (or a compression roller) is installed in the take-off device (card web extraction device), and the degree of orientation of each structural fiber can be adjusted, and 6) the obtained fibrous web (1) is homogeneous, and thus is the most desirable method. Furthermore, a card web in which a thin web sheet of two or more layers has been laminated is particularly desirable because it comes to be extremely homogeneous. Regarding a card web which has been formed in such a fashion, because the amount of monomer aqueous solution 2 applied cannot be increased when the METSUKE is low, it is preferable that the METSUKE be high; on the other hand, this becomes a disadvantage in terms of economy. Because it is assumed that a disposable diaper is most comfortable when the thickness of the

absorbent material used is 2 to 15 mm, the METSUKE should be adjusted within a range of 10 to 100 g/m^2.

Owing to the fact that the structural fibers of fibrous web 1 are made to be oriented in one direction of the fibrous web, such as the direction in which the machine is running [literally, "the mechanical direction"], the hydrophilic fibers come to be in close proximity to each other and become easy to arrange in a parallel fashion, and it becomes easy for monomer aqueous solution 2 to become attached along the lengths of the fibers. That is to say, when each fiber exists independently in a random direction, monomer aqueous solution 2 slips down along the length of the fibers and is not maintained on the fibers. However, when the fibers are in close proximity to each other and two or more exist in a parallel state, monomer aqueous solution can be maintained in the spaces between the fibers.

The orientation of the fibers which constitute fibrous web 1 can be controlled by the utilization of a special card for nonwoven fabrics, a crimped form of the fiber, or a combination thereof. That is to say, when the form of the crimping of the fiber is mechanical crimping of a two-dimensional straight-chain form, each fiber can easily be arranged in a mechanical direction. When the form of crimping is three-dimensional multi-layered crimping formed by side-by-side spinning of two types of polymer or one-sided cooling of two fused spun threads, each fiber curls up and the fiber arrangement becomes multi-layered, so that the tendency for the orientation to become random becomes strong. Consequently, by adjusting the strength of three-dimensional multi-layered crimping, it is possible to control the orientation ratio of the width direction and the direction in which the machine is running, i.e. the degree of orientation, of the fiber. Furthermore, the degree of orientation can be controlled by using special cards developed for nonwoven fabrics, mechanically converting the orientation of the fibers into a multi-layered orientation and randomizing the arrangement. With this type of special card, a special take-off device is installed immediately after the doffer and fibrous web 1, in which the fibers have been oriented in the direction in which the machine is running, can be taken out without further steps; furthermore, it is possible to subject the fibers, which have once been arranged in the direction in which the machine is running, to further multilayerization, randomize the orientation and remove [the fibers]. For example, when a take-off device equipped with a with a condensing roller designed in such a way that the rotation is in the direction opposite to that of the doffer and the surface

speed is a speed 5 to 60% lower than that of the doffer is installed immediately after the doffer, the fibers on the doffer are condensed 5 to 60% in the direction in which the machine is running while being transferred to the condensing roller and, at this time, the arrangement in the direction in which the machine is running of the fibers is put into disorder, and multilayerization and randomizing of the orientation are brought about. At this time, the angle of the pincushion of the condensing roller is arranged so as to be opposite to the doffer, the multilayerization of each fiber is intensified and the bulkiness of the fibrous web increases. The main point is that the randomization of the card and the crimping state of the fibers should be selected, as suitable, in accordance with the adhesion of the monomer aqueous solution, the bulkiness, and the diffusion directionality or swelling directionality (the width direction or the direction in which the machine is running) during the absorption of urea of the absorbent material.

A example of a roller card capable of manufacturing a fibrous web (1) suitable for the present invention is shown in Figure 8. In this figure, 16 is a cylinder roller, 17 is a worker roller, 18 is a stripper roller, 19 is a feed roller, 20 is a taker-in roller, 21 is a doffer roller and 22 is a take-off device. The surface speed of worker roller 17 is lower than that of cylinder roller 16, and performs the task of scratching off the thick layer on cylinder roller 16. Furthermore, the surface speed of stripper roller 18 is higher than that of worker roller 17 but lower than that of cylinder roller 16; it performs the task of scratching off the fibers from worker roller 17 and moving them toward cylinder roller 16. Example of cards of this type of structure include a random card from the Herugesu [transliteration] Co. of West Germany.

Furthermore, an example of a flat card capable of manufacturing a fibrous web (1) suitable for the present invention is shown in Figure 9. In this figure, 23 is a top pincushion, 24 is a nose plate, 25 is a feed roller and 26 is a taker-in roller. The surface speed of top pincushion 23 ranges from slow motion to stillness, and performs the task of arranging the thick fiber layer on cylinder roller 16. Examples of this type of flat roller include a tandem master roller made by the Hollingworth [transliteration] Co. of the United States.

The heat treatment for the card web pertaining to the present invention can be carried out using a widely known air-through-type [transliteration] dryer for dry

non-woven fabrics, as shown in Figure 10, in which hot blast 29 produced by heater 27 and blower 28 passes through web layer 30.

As discussed above, because the binder fibers which fuse with and adhere to the base fibers at a relatively low temperature are mixed and disseminated and heat treatment is executed in a completely dry state, the method for manufacturing a dry non-woven fabric possesses the characteristics that there are no problems with the stability of the reagents with respect to skin, and that fibrous web 1, which possesses relatively large vacant spaces and high compression elasticity as compared to [those which result from] a method in which a liquid binder reagent is applied and the card web is treated in a dampened state, can be formed. Regarding the conditions for heat treatment, the temperature should be set between the softening point of the low-fusing point polymer of the binder fiber and said softening point + 80°C, while the speed of the hot blast of the air-through [transliteration] may be selected at 0.5 to 3.0 m/sec and the heat treatment time should be set in a range of 1 to 30 sec.

However, because the diffusion of urine into the absorbent material which has been formed and the adhesion of monomer aqueous solution 2 to fibrous web 1 can be caused to increase by subjecting the surface of the structural fibers of fibrous web 1 in the absorbent material based on the present invention to hydrophilicizing treatment, it is desirable to subject the surfaces of the structural fibers to a hydrophilicizing treatment.

This hydrophilicizing treatment for the surfaces of the structural fibers can easily be accomplished if a surfactant with a high wetting effect is imparted to the fiber surfaces. A nonionic surfactant such as a polyoxyethylene alkyl ether, polyoxyethylene phenol ether, polyoxyethylene sorbitan [transliteration] fatty acid ester, a polyoxyethylene alkyl fatty acid ester or a polyoxyethylene oxypropylene block polymer, anionic surfactants such as a fatty acid salt, an alkylnaphthalene sulfonic acid salt, a dialkyl succinic acid salt, an alkyl phosphoric acid ester salt or a high-order alcohol phosphoric acid ester salt, or a cationic surfactant such as a alkylamine salt or an alkyl quaternary ammonium salt can be used; among these possibilities, it is desirable to use a surfactant of HLB 10 or above selected from among the group of nonionic surfactants and the group of anionic surfactants.

In common thermoplastic synthetic fibers, an anionic or cationic surfactant is commonly used as a static preventing agent in order to avoid difficulties owing to static electricity; however, it is, naturally, possible to use a surfactant possessing a static preventing effect selected from among the abovementioned cationic surfactants or anionic surfactants which possess a high wetting effect, so that the two effects can thus be imparted at the same time.

Furthermore, because it is necessary that an absorbent material in which a highly absorbent resin has been fixed in structural fibers repeatedly move urine which has been discharged along the structural fibers, it is desirable to carry out a durable hydrophilicizing treatment [literal translation].

It is suitable to use an oligomer containing a hydrophilic group as a durable hydrophilicizing treatment agent. Furthermore, regarding polyester fibers, a polyester oligomer containing a hydrophilic group can be used. In this case, it is desirable from the standpoints of bonding power with the polyester fiber polymer substrate and dispersibility in the hydrophilicizing treatment solution that the molecular weight of the oligomer component be in a range of 300 to 6000. The formation of a copolymer containing terephthalic acid and isophthalic acid as an acid component derived from, for example, a dicarboxylic acid, in such a way that the oligomer component undergoes fusion eutectization [literal translation] at a relatively low temperature, is favorable.

1) a wettable powder, 2) an acidic group derived from sulfonic acid, phosphonic acid or a carboxylic acid, or an alkali metal salt thereof, or 3) a nitrogenous basic salt or an ionizable salt thereof can be used as the abovementioned hydrophilic groups; among these possibilities, a substance based on a polyoxyalkyl group is most favorable. A polyoxyethylene oxypropylene block copolymer, which is a copolymer of polyethylene glycol and polypropylene glycol, is particularly desirable as an example of a polyoxyalkyl group.

Because an oligomer containing a hydrophilic group which possesses durable hydrophilic properties generally diminishes the wetting effect, a desirable hydrophilic effect can be obtained when such an oligomer is used, in accordance with necessity, in tandem with a surfactant with a high wetting effect as mentioned above. The amounts of these hydrophilic treatment agents attached should be in a

range of 0.05 to 2.0 wt % with respect to the structural fibers. As a concrete example of such imparting of hydrophilic properties to the fiber surfaces, a spinning oil and a hydrophilic property imparting agent should be mixed during the oiling process of a spinning process based on a kiss roller, and imparted together to the spun fibers or, after drawing has been performed, the hydrophilic property imparting agent should be imparted by disseminating or dropping it onto the stretched fiber tow before the pressure crimping device. When heat treatment (curing) is necessary in the imparting of durable hydrophilic properties, the stretched tow which has been subjected to crimp-molding should be, either without further steps or after being cut into short fibers, dried using an air-through-type dryer (dry heat treatment). The heat treatment should be carried out with dry heat for 2 to 15 min at a temperature in a range of 140 to 180°C.

In the present invention, an evaluation of the hydrophilic properties of the structural fibers can easily be made by using a cotton cluster obtained by subjecting the fibers to card opening and determining the speed of sedimentation in water. This speed of sedimentation in water can be determined by, as shown in Figure 11, making 1 g of a cotton sheet round and preparing a cotton ball (31) of diameter 4 cm, allowing it to drop from a height of 1 cm from the surface of the water, and measuring the time (sec) from the time when the cotton ball reaches the water surface (32a) to the time when it is absorbed in the water (32b) by means of a stopwatch.

With the present invention, it becomes possible to control the adhesion state of the highly absorbent resin owing to the fact that, after a suitable amount of a fiber which has been subjected to water-repellency treatment has been mixed with fibers which have been made hydrophilic, monomer aqueous solution 2 is selectively made hydrophilic caused to selectivity adhere. That is to say, in the component in which many fibers which contain fibers which have been subjected to water-repellency treatment intersect, it becomes difficult for large drops of monomer aqueous solution 2 to be captured and, as a result, because it becomes difficult for large resin grains to be formed, it becomes possible to make the size of the grains of the highly absorbent resin relatively fine.

Water-repellent fibers suitable for use in the present invention should essentially not be wet with monomer aqueous solution 2, and can easily be obtained

if a widely known water repellant is imparted to the surfaces of the fibers or caused to be disseminated in the polymer which forms the fibers. Substances in which an organic salt of zinc, tin or lead, or another substance, is added as a catalyst which promotes oxidation and condensation into an emulsion solution of silicon monomers such as methylhydrogen polysiloxane and/or dimethylpolysiloxane are widely known as such water repellants; a water repellency effect which does not fade with time can be obtained when, after impregnation into the fibers, drying is performed and, afterwards, curing is performed. Naturally, it is also possible to bring about an increase in durability by substituting a suitable group, such as an amino group or an alkyl group or alkyl group, for the OH terminus of methylhydrogen polysiloxane and/or dimethylpolysiloxane.

In addition, a similar water repellency effect can be obtained by means of the present invention if, after an emulsion solution of a fluorocarbon monomer derived from an acrylic acid fluoroalkyl ester and a perchloromonocarboxylic acid complex salt is impregnated into the fibers, drying and curing are performed, or if a polyolefin wax is independently applied to the fiber surfaces. Such a water repellant is sufficient if 0.05 to 2.0 wt % with respect to the fibers is caused to adhere.

It is desirable that the hydrophilic properties of the fibers used in the present invention be such that the speed of sedimentation in water be 30 seconds or below. Furthermore, it is desirable that the water repellent properties of the water repellent fibers, on the other hand, be such that the sample does not undergo sedimentation even after it has fallen into the water and floated on the surface for 5 seconds.

When hydrophilic fibers and water-repellent fibers are used jointly in the present invention, the proportion thereof should be in a range of 90 : 10 to 10 : 90. When the proportion of water repellent fibers is below 10 wt %, the effect whereby the adhesion of monomer aqueous solution 2 becomes fine becomes insufficient and, when 90 wt % is exceeded, the amount of monomer aqueous solution 2 which adheres to fibrous web 1 is absolutely insufficient, so that only an absorbent material with markedly low absorption capacity can be obtained.

However, the bulk, compression recovery factor, tensile strength and tensile elasticity are determined as follows.

Bulkiness (cc/g) is determined by repeatedly laminating four samples obtained by cutting fibrous web 1 into squares of sides 10 cm (concerning the directions of the sides, they are made consistent in the width direction and in the direction in which the machine is running) in an alternating fashion in the width direction and the direction in which the machine is running, placing a methyl methacrylate resin plate and a weight on the top thereof, applying a load of 0.5 g/cm^2 for 10 min and determining the volume V_1 (cc) of the fibrous web layer at this time, and dividing this V_1 by the weight of the fibrous web, which has been weighed beforehand.

As for the compression recovery factor, a load of 50 g/m^2 is placed upon the fibrous web layer the bulk V_1 (cc) of which has been determined, and the volume V_2 (cc) is determined after the system has been allowed to stand for 5 hours; next, the weight is put back and the volume V_3 after a load of 0.5 g/cm^2 has been applied for 10 minutes is determined. The compression recovery factor (%) can be determined from V_1, V_2 and V_3, in accordance with the following formula.

$$\text{compression recovery factor (\%)} = V_3 - V_2/V_1 - V_2 \times 100$$

Furthermore, the tensile strength and tensile elasticity of the fibrous web are determined using a test sheet whereby the sample has been cut into a rectangle of length 15 cm and width 2.5 cm (the long side is made to be consistent in the width direction and in the direction in which the machine is running). Then, both ends of the test sheet are inserted into chucks and, using tension, the length of the sample is adjusted to 10 cm. Next, elongation is performed at a speed of elongation of 100%/min and the curve of the relationship between growth and applied power is determined. The tensile strength (g/25 mm) and tensile elasticity (%) when the test sheet has ruptured can be discerned from this relationship curve.

Furthermore, the tensile strength (g/25 mm) and tensile elasticity (%) of fibrous web 1 are determined for both the mechanical direction and the width direction.

The absorption capacity of the absorbent material obtained by means of the method of the present invention, that is to say, the absorption multiplier and the

water retention multiplier, are determined using a test sheet manufactured by cutting a sample which has been vacuum dried for 2 hr at 80°C and subjected to humidity conditioning for 8 hr in an atmosphere of 25°C and relative humidity 60% into a square of 10 cm sides (concerning the directions of the sides, they are made consistent in the width direction and in the direction in which the machine is running). First, the weight of the test sheet (a) (grams) is determined. Next, the test sheet is introduced into a 250 mesh nylon cloth bag of length 20 cm and width 15 cm and immersed in a shallow container into which a test solution (physiological brine, 0.9 wt % NaCl) prepared ahead of time has been introduced, and absorption of the test solution is brought about. After one hour of immersion, the test sheet and the nylon bag are removed and placed on a 10 mesh metal screen, a methyl methacrylate resin plate and a weight are placed on the top thereof, and the cutting off of water is carried out for 15 min under a pressure of 35 g/cm². Afterwards, the test sheet is removed and the weight (b) (grams) is determined. Then, in addition, the test sheet is returned to the nylon bag and, along with the nylon bag, is placed on the side wall of the rotating tank of a centrifuge, and centrifugal dehydration is carried out for 90 seconds by means of a centrifugal force of 150 G, after which this test sheet is removed from the nylon bag and the weight (c) (grams) is determined.

Then, the absorption multiplier and the water retention multiplier can be determined from (a), (b) and (c), in accordance with the following formulae.

absorption multiplier (g/g) = (c) - (a)/ (a)
water retention multiplier (g/g) = (b) - (a)/ (a)

Below, the present invention is explained in concrete terms by means of practical examples.

(Practical Example 1)

Ethylene glycol and a dicarboxylic acid component of a proportion of 60 mol % terephthalic acid and 40 mol % isophthalic acid were subjected to esterification, after which 70 parts of a 6 denier, 51 mm polyethylene terephthalate fiber of relative viscosity 1.65 possessing a hollow cross-section (hollow proportion 20%), which was essentially derived from structural units of ethylene terephthalate, was mixed with

30 parts of 4 denier, 51 mm core-sheath-type fibers in which a polyester copolymer of relative viscosity (determined in a mixture solvent of phenol and tetrachloromethane, at a concentration of 0.5 g/100 cc and a temperature of 20°C) 1.38 and fusion softening point 110°C, which was obtained by polycondensation, was arranged in the sheath and polyethylene terephthalate of relative viscosity 1.55 and fusion softening point 256°C was arranged in the core, an opener [Translator's note: the original reads "fopuna", an apparent misprint; the intended meaning of "opener" has been inferred from the context.] was used and short fibers which were uniformly subjected to entanglement and opening were supplied to the flat card shown in Figure 9, carding was carried out at a speed of 50 m/min and a card web of METSUKE 35 g/m^2 was formed.

Then, this card web was continuously guided to the heat treatment device for the flat belt-type air slew method shown in Figure 10, a hot blast (blast speed: 1.5 m/sec) of 160°C was caused to pass through the card web for 10 minutes, the binder fibers were fused, fibers adhered to each other, and a fibrous web of favorable morphological stability was formed.

The characteristics of the fibrous web thus obtained are shown in Table 1.

Table 1

	Practical Example 1
METSUKE of the Fibrous Web (g/m^2)	35
Bulkiness of the Fibrous Web (cc/g)	1.20×10^2
Compression Recovery Factor (%)	82
Tensile strength in the direction in which the machine is running (g/25 mm)	430
Tensile elasticity in the direction in which the machine is running (%)	25
Tensile strength in the width direction (g/25 mm)	80
Tensile elasticity in the width direction (%)	120

Practical Example 2

The fibrous web obtained in the earlier Practical Example 1 was guided into the polymerization device shown in Figure 1 while being caused to travel at 50 m/min and, in this device, the nip-type coating roller shown in Figure 3 was used, 1.67 wt % with respect to the monomer of a photopolymerization initiator was added and dissolved and the monomer aqueous solution, which has been heated to 40°C, was applied to the fibrous web so as to make the amount of the monomer 200

g/m², after which the ultraviolet beam irradiation device shown in Figure 2 was used and irradiation was performed with an ultraviolet beam at a radiation dosage of 500 millijoules/cm², after which [the product] was guided to the polymerization tank, which was continuously maintained at a temperature of 80°C and a relative humidity of nearly 100%, and polymerization was carried out.

Here, with regard to the monomer aqueous solution, a substance in which 0.085 wt % N,N'-methylbisacrylamide with respect to the acid monomer had been added was used as a cross-linking agent in the monomer, in which 60% of all of the carboxyl groups in acrylic acid had been neutralized by means of potassium hydroxide. Furthermore, the abovementioned compound [II] was used in the photopolymerization initiator.

Polymerization was directly initiated by means of the irradiation of an ultraviolet beam and the polymerization reaction was completed in approximately 8 seconds in the polymerization tank while being accompanied by the generation of heat. Afterwards, continuing on, the accelerated electron beam irradiation devices shown by the numeral 9 in Figure 1, which face each other in an alternating fashion, were used and electron beams of 2 megarads each, for a total of 4 megarads, were irradiated onto the two surfaces of the fibrous web, the remaining monomer was subjected to polymerization and cross-linking was carried out.

The properties of the absorbent material thus obtained are shown in Table 2.

(Comparative Example 1)

As the fibrous web obtained in the earlier Practical Example 1 was being fed at 50 m/min, hydrogen peroxide was added so as to attain a proportion of 1.67 wt % with respect to the acid monomer, mixing and dissolution were performed, and the monomer aqueous solution, which had been heated to 40°C, was applied such that the weight of the monomer became 200 g/m², after which 0.34 wt %, with respect to the monomer, of a 5 wt % aqueous solution of L-ascorbic acid was sprayed onto the fibrous web, [this product] was immediately guided to a polymerization tank which had been maintained at an atmosphere of temperature 80°C and humidity 80% and polymerization was carried out; aside from these operations, operations similar to

those in Practical Example 2 were performed, and an absorbent material was obtained.

The properties of the absorbent material thus obtained are shown in Table 2.

Table 2

	Practical Example 2	Comparative Example 1
Absorption Multiplier (g/g)	41	37
Water Retention Multiplier (g/g)	28	24
Thickness of the Absorbent Material (mm)	3.8	1.8
Softness of the Absorbent Material	Possessed resiliency but not softness	Hard in plate form

(Merits of the Invention)

By means of the method for manufacturing an absorbent material based on the present invention as explained above, because a highly absorbent resin monomer which has been applied to a fibrous web is converted into a resin by means of a uniform polymerization reaction, an absorbent material which possesses superior absorption capacity can be manufactured. Furthermore, an absorbent material which possesses a bulky structure, is soft, absorbs urine and feels extremely comfortable in that it swells sufficiently can be obtained, and an absorbent material whereby the intrinsic absorption capacity of the resin has been effectively realized and which is suitable for use even in troublesome disposable diapers can be obtained.

Furthermore, when the present invention is put into practice, the formation of the fibrous web, the application of the monomer aqueous solution to this fibrous web, the irradiation with ultraviolet beams of the fibrous web to which the monomer aqueous solution has been applied, the reaction treatment in the polymerization tank and each operation for the decreasing of the unreacted monomer which is executed in accordance with necessity can be carried out continuously and, by such actions, the cost of manufacturing the absorbent material can be greatly reduced.

4. Brief Description of the Figures

Figure 1 is a block diagram which shows a manufacturing device for absorbent materials which is suitable for executing one example of the method for manufacturing an absorbent material based on the present invention; Figure 2 is a block diagram which shows an example of an ultraviolet beam irradiation device; Figure 3 is a block diagram which shows an example of a coating device for a monomer aqueous solution; Figure 4 is a block diagram which shows an example of a scattering device for a monomer aqueous solution; Figure 5 is a block diagram which shows an example of a dipping device for a monomer aqueous solution; Figure 6 is a block diagram which shows an example of a kiss coating device for a monomer aqueous solution; Figure 7 is a magnified diagram for the purpose of explaining the application state when the monomer aqueous solution is applied at a high speed; Figure 8 is a schematic side-view diagram which shows an example of a roller card; Figure 9 is a schematic side-view diagram which shows an example of a flat card; Figure 10 is a block diagram which shows an example of an air-through-type dryer; Figure 11 is a side-view diagram which for the purpose of explaining a method for evaluating hydrophilic properties.

1, fibrous web; 2, monomer aqueous solution; 3, ultraviolet beam irradiation device; 4, polymerization tank; A and B, absorbent materials.

Figure 1

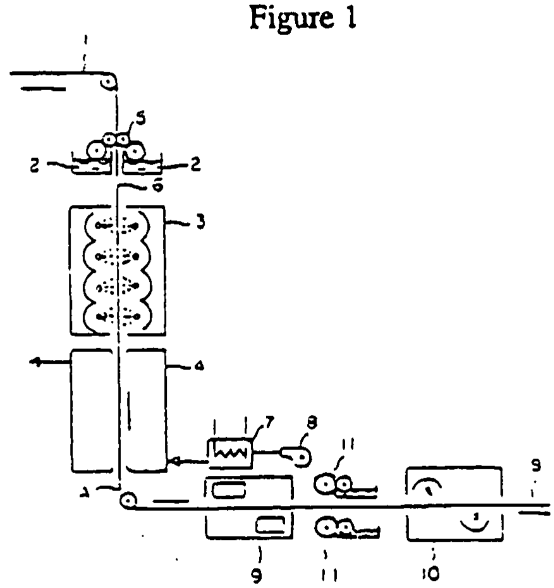


Figure 2

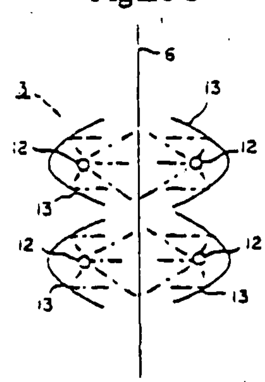


Figure 3

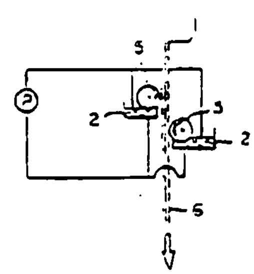


Figure 4

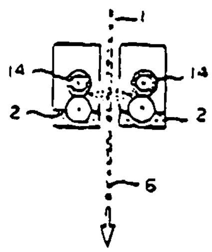


Figure 5

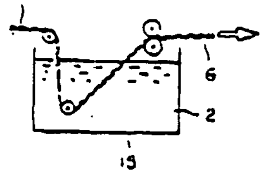


Figure 6

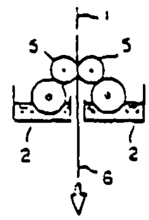


Figure 7

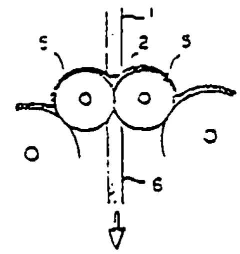


Figure 8

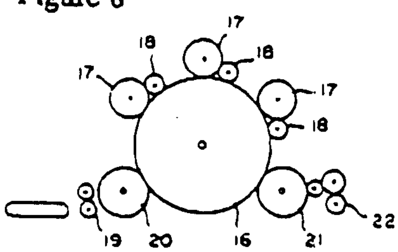


Figure 9

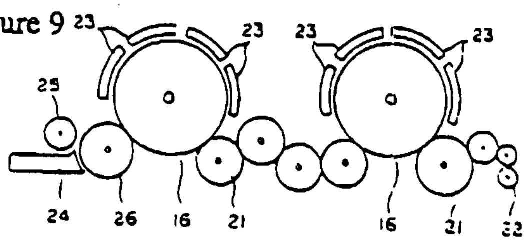


Figure 10

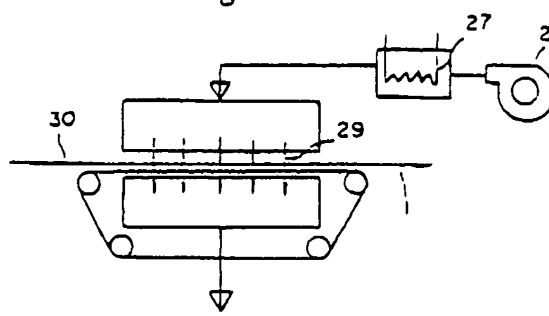


Figure 11